DAC

PATENT
040474

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants:	Tamio ENDO et al.	Confirmation:	2166
Serial No.:	10/510,245	Art Unit:	1746
Filed:	06-28-2005	Examiner:	A. Markoff
For:	RESIST REMOVING APPARATUS AND METHOD OF MOVING RESIST		

SECOND RENEWED PETITION UNDER 37 C.F.R. §1.47

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

September 27, 2007

Sir:

Further to the Renewed Petition under 37 C.F.R. §1.47(a) filed July 23, 2007,and the original Petition filed June 28, 2005, included with this Second Renewed Petition is a Declaration for U.S. Patent Application signed by three of the four inventors of the present invention on behalf of themselves and a non-signing joint inventor, Atsushi Sato, whose last known address was 1-18-208, Kouya 2-chome, Ichikawa-shi, Chiba 272-0013, JAPAN. The Declaration meets all requirements of 37 C.F.R. §1.47(a), including item (4).

The petition fee was previously paid; however, if a fee is necessary, the Commissioner is hereby authorized to charge any fee required to secure entry of this Renewed Petition and the accompanying documentation to Deposit Account No. 01-2340.

Submitted concurrently is the Second Renewed Declaration of Takayoshi Kokubun, Applicant's Japanese patent representative, which sets forth facts in support of the present Renewed Petition. As

outlined in the accompanying Renewed Declaration and supported by documentary evidence, Mr. Kokubun and his staff were unable to locate or contact Atsushi Sato despite diligent effort involving multiple attempts and methods, including via the Internet and telephone directory. The Second Renewed Declaration supports the position that the nonsigning inventor could not be found or reached and satisfy the requirements of 37 C.F.R. §1.47(a), including items (2) and (4).

In view of the foregoing statement and accompanying documents, the USPTO is respectfully requested to accept the Declaration for U.S. Patent Application, and grant Applicants' Renewed Petition under 37 C.F.R. §1.47(a).

Respectfully submitted,
KRATZ, QUINTOS & BROOKS, LLP

BY: 

George N. Stevens
Reg. No. 36,938

Docket No. 040474
1420 K Street, NW, Suite 400
Washington, DC 20005
(202) 659-2930


23850
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GNS:rk

DECLARATION FOR U.S. PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention **entitled:**

RESIST REMOVING APPARATUS AND METHOD OF REMOVING RESIST

the specification of which is attached hereto unless the following is checked

☒ was filed on _____ as United States Application Number **10/510,245** or was filed on **April 15, 2003** as PCT International Application Number **PCT/JP03/04751** and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 (a) – (d) of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application for which priority is claimed.

(List prior foreign applications. See note A)	(Number)	(Country)	(Day/Month/Year Filed)	Priority Claimed
	2002-113550	Japan	16/April/2002	☒ Yes ☐ No
				☐ Yes ☐ No
				☐ Yes ☐ No
				☐ Yes ☐ No

(See note B) ☐ See attached list for additional prior foreign applications

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

(List prior U.S. Applications)	(Application Serial No.)	(Filing Date)	Status
			☐ Patented ☐ Pending ☐ Abandoned
			☐ Patented ☐ Pending ☐ Abandoned
			☐ Patented ☐ Pending ☐ Abandoned

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

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PATENT TRADEMARK OFFICE

Please direct all communications to the following address:

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PATENT TRADEMARK OFFICE

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Title 18 of the United States Code, § 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor (given name, family name) **Tamio ENDO**
Inventor's signature 遠藤民夫 Date June 25, 2007
Residence **Tokyo** Citizenship **Japan**
Post Office Address **c/o SIPEC CORPORATION**
7th Floor, Nissei Ohtsuka 3cho-me Bldg., 3-11-6, Ohtsuka, Bunkyo-ku, Tokyo 112-0012 Japan

Full name of second inventor (given name, family name) **Atsushi SATO (Missing Inventor)**
Inventor's signature _____ Date _____
Residence **Chiba** Citizenship **Japan**
Post Office Address **1-18-208, Kouya 2-chome, Ichikawa-shi, Chiba 272-0013 Japan**

Full name of third inventor (given name, family name) **Yasuhiko AMANO**
Inventor's signature 天野泰彦 Date June 25, 2007
Residence **Tokyo** Citizenship **Japan**
Post Office Address **c/o SIPEC CORPORATION**
7th Floor, Nissei Ohtsuka 3cho-me Bldg., 3-11-6, Ohtsuka, Bunkyo-ku, Tokyo 112-0012 Japan

Full name of fourth inventor (given name, family name) **Tetsuji TAMURA**
Inventor's signature 田村哲司 Date June 25, 2007
Residence **Okayama** Citizenship **Japan**
Post Office Address **c/o MITSUI ENGINEERING & SHIPBUILDING CO., LTD. TAMANO WORKS**
1-1, Tama 3-chome, Tamano-shi, Okayama 706-8651 Japan

F1143P-WO-US

PATENT
040474

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants:	Tamio ENDO et al.	Confirmation:	2166
Serial No.:	10/510,245	Art Unit:	1746
Filed:	06-28-2005	Examiner:	A. Markoff
For:	RESIST REMOVING APPARATUS AND METHOD OF MOVING RESIST		

SECOND RENEWED DECLARATION IN SUPPORT OF PETITION UNDER 37 C.F.R. §1.47

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I, Takayoshi Kokubun, declare as follows:

1. Messrs. Tamio Endo, Atsushi Sato, Yasuhiko Amano, and Tetsuji Tamura are joint inventors and applicants with respect to the above-identified application.

2. Atsushi Sato cannot be contacted or located, despite repeated diligent efforts, recounted below, to reach him and to ascertain his whereabouts.

3. An inquiry at his last known business office revealed that Atsushi Sato had retired, and no one had useful information regarding how to contact him.

4. In another attempt to reach Atsushi Sato by mail, on September 27, 2004, a letter was sent to his last known residence (1-18-208, Kouya 2-chome, Ichikawa-shi, Chiba 272-0013, JAPAN),

together with an English language translation of the present application, including specification, claims, abstract, and drawings; a copy of WO 03/088337; a Declaration and Power of Attorney; and am Assignment. These items were returned because Atsushi Sato had moved, with no forwarding address provided. Copies of the returned items and mailing envelope are attached, together with an English language translation of the letter to Mr. Sato and mailing envelope.

5. Several telephone calls were placed to Atsushi Sato at his last known land line and cellular number, but no one answered the telephone. In addition, a directory assistance operator was questioned regarding the telephone number of Atsushi Sato, but no listing could be found in any telephone directory.

6. An attempt was made to contact Atsushi Sato via telecopier, but his last known facsimile number is no longer in use. Attached is a copy of an unsuccessful transmission sheet and translation thereof received when attempting to contact Atsushi Sato at his last known facsimile number.

7. An e-mail message was then sent to Atsushi Sato at his last known e-mail address, but it was not deliverable. Attached is a copy of an undeliverable message received when attempting to contact Atsushi Sato at his last known e-mail address, with the Japanese portions translated into English.

8. An Internet search similarly failed to turn up any information as to the location of Atsushi Sato. Attached is a copy of the results of the Internet search.

9. Despite diligent effort, none of the attempts to contact Atsushi Sato was successful. His whereabouts remain unknown, and it is respectfully submitted that coinventor Atsushi Sto is unavailable to execute the concurrently submitted Declaration and Power of Attorney.

10. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true and, further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the present application or any patent that issues therefrom. Supporting evidence will be supplied upon receipt.

Respectfully submitted,

Sep. 3, 2007
Date

Takayoshi Kokubun
Takayoshi Kokubun

(Translation of the returned letter)

September 27, 2004

Dear Mr. Atsushi SATO

KOKUBUN International Patents & Trademarks
5F, 1-17-8, Higashi-Ikebukuro,
Toshima-ku, Tokyo 170-0013
Tel: (03) 3590-8901
Fax: (03) 3590-4801

Re: International application No.: PCT/JP03/04751
Title: Resist removing apparatus and method of removing resist
Corresponding to: JP2002-113550
(Designated: US, EP, KR, CN)
Client's Ref: UCRI029
Our Ref: F1143P-WO

We are enclosing a copy of the English translation of the above application, including specification, claims, abstract and drawings for the entry into the national phase. Please review these translations carefully and let us know if you consent or not.

If you consent to these translations, please execute return the enclosed forms of Declaration and Power of Attorney and Assignment, by October 8, 2004.

Encl(s):
(1) English translation of the International application
(2) International publication (in Japanese)
(3) Declaration and Power of Attorney form
(4) Assignment form

Returned letter

書類送付のご案内

平成１６年９月２７日

佐藤　淳　様

東京都豊島区東池袋１－１７－８
池袋TGホーメストビル(5F)〒170-0013
國分特許事務所
ＴＥＬ (03) 3590-8901 (代表)
ＦＡＸ (03) 3590-4801
担　当：　小菅／柴崎

ＰＣＴ特許出願：ＰＣＴ／ＪＰ０３／０４７５１
「レジスト除去装置及びレジスト除去方法」
（対応日本国出願：特願２００２－１１３５５０）
（指定国：ＵＳ、ＥＰ、ＫＲ、ＣＮ）
貴社整理No.　ＵＣＲＩ０２９
弊所整理No.　Ｆ１１４３Ｐ－ＷＯ　の件

拝啓　時下ますますご清栄のこととお慶び申し上げます。

さて、標記出願に関しまして、各国国内段階への移行手続に使用します英文明細書及び図面原稿をお送り致しますので、ご検討宜しくお願い申し上げます。

また、米国国内移行手続に使用しますDeclaration and Power of Attorney及びAssignmentのフォームを同封致しますので、所定の箇所にサインをしていただきまして、

平成１６年１０月８日

まで弊所あてご返送下さいますようお願い申し上げます。

敬　具

添付書類：

(1) 英文明細書及び図面原稿	各１通
(2) 和文明細書及び図面（参照用）	各１通
(3) Declaration and Power of Attorney	１通
(4) Assignment	１通

(Translation of the returned mailing envelope)

[Delivery-certified mail]
Date of shipping: September 27, 2004

To:
Atsushi SATO
1-18-208, Kouya 2-chome, Ichikawa-shi, Chiba 272-0013 Japan

[Not delivered since the addressee has moved, and forwarding address is not available]

Returned on September 30, 2004

Bar code 120-04-47084-4

KOKUBUN International Patents & Trademarks
5F, 1-17-8, Higashi-Ikebukuro, Toshima-ku, Tokyo 170-0013
TEL. 03 (3590)8901 FAX. 03 (3590)4801

Returned mailing envelope

2 7 2 0 0 1 3

〒272-0013

千葉県市川市高谷 2-1-18

エステート31 208号

佐藤 淳 様

転居先不明で配達できません 市川

RECEIVED SEP 2004 KOKUBUN

120-04-47084-4

配達証明

國分特許事務所

KOKUBUN International Patents & Trademarks

〒170-0013 東京都豊島区東池袋1丁目17番8号 池袋TGホーメストビル5階

TEL.03 (3590) 8901 FAX.03 (3590) 4801

F1143P-WO-US

Docket No. ____

ARMSTRONG, KRATZ, QUINTOS, HANSON & BROOKS, LLP

Declaration and Power of Attorney for Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration
日本語宣言書

私は、以下に記名された発明者として、ここに下記の通り宣言する：

As a below named inventor, I hereby declare that:

私の住所、郵便の宛先そして国籍は、私の氏名の後に記載された通りである。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明について、特許請求範囲に記載され、且つ特許が求められている発明主題に関して、私は、最初で、最先且つ唯一の発明者である（唯一の氏名が記載されている場合）か、或いは最初、最先且つ共同発明者である（複数の氏名が記載されている場合）と信じている。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

_____

_____

_____

_____

上記発明の明細書はここに添付されているが、下記の欄がチェックされている場合は、この限りでない：

the specification of which is attached hereto unless the following box is checked:

☐ _____の日に出願され、
この出願の米国出願番号またはPCT国際出願番号は、
_____であり、且つ
_____の日に補正された出願（該当する場合）

☑ was filed on April 15, 2003
as United States Application Number or
PCT International Application Number
PCT/JP03/04751 and was amended on
_____ (if applicable).

私は、上記の補正書によって補正された、特許請求範囲を含む上記明細書を検討し、且つ内容を理解していることをここに表明する。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第３７編規則１．５６に定義されている、特許性について重要な情報を開示する義務があることを承認する。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

Docket No. ____ ARMSTRONG, KRATZ, QUINTOS, HANSON & BROOKS, LLP

Declaration and Power of Attorney for Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration
日本語宣言書

委任状： 私は本出願を審査する手続きを行い、且つ米国特許商標庁との全ての業務を遂行するために、記名された発明者として、下記の弁護士及び／または弁理士を任命する。

POWER OF ATTORNEY: As a named inventor, I hereby appoint The following attorney(s) and/or agent(s) to prosecute this Application and transact all business in the Patent and Trademark Office connected therewith.

23850
PATENT TRADEMARK OFFICE

全ての通信は下記の住所へ送付されたい。

Please direct all communications to the following address:

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PATENT TRADEMARK OFFICE

唯一または第一発明者氏名	Full name of sole or first inventor Tamio ENDO
発明者の署名 日付	Signature Date
住所	Residence Tokyo
国籍	Citizenship Japan
郵便の宛先	Post Office Address c/o SIPEC CORPORATION, 7th Floor, Nissei Ohtsuka 3cho-me Bldg., 3-11-6, Ohtsuka, Bunkyo-ku, Tokyo 112-0012 Japan
第二共同発明者がいる場合、その氏名	Full name of second joint inventor, if any Atsushi SATO
発明者の署名 日付	Signature Date
住所	Residence Chiba
国籍	Citizenship Japan
郵便の宛先	Post Office Address 1-18-208, Kouya 2-chome, Ichikawa-shi, Chiba 272-0013 Japan
第三共同発明者がいる場合、その氏名	Full name of third joint inventor, if any Yasuhiko AMANO
発明者の署名 日付	Signature Date
住所	Residence Tokyo
国籍	Citizenship Japan
郵便の宛先	Post Office Address c/o SIPEC CORPORATION, 7th Floor, Nissei Ohtsuka 3cho-me Bldg., 3-11-6, Ohtsuka, Bunkyo-ku, Tokyo 112-0012 Japan

第四共同発明者がいる場合、その氏名		Full name of third joint inventor, if any Tetsuji TAMURA
発明者の署名	日付	Signature Date
住所		Residence Okayama
国籍		Citizenship Japan
郵便の宛先		Post Office Address c/o MITSUI ENGINEERING & SHIPBUILDING CO., LTD. TAMANO WORKS 1-1, Tama 3-chome, Tamano-shi, Okayama 706-8651 Japan
第五共同発明者がいる場合、その氏名		Full name of eighth joint inventor, if any
発明者の署名	日付	Signature Date
住所		Residence
国籍		Citizenship
郵便の宛先		Post Office Address
第六共同発明者がいる場合、その氏名		Full name of eighth joint inventor, if any
発明者の署名	日付	Signature Date
住所		Residence
国籍		Citizenship
郵便の宛先		Post Office Address
第七共同発明者がいる場合、その氏名		Full name of eighth joint inventor, if any
発明者の署名	日付	Signature Date
住所		Residence
国籍		Citizenship
郵便の宛先		Post Office Address
第八共同発明者がいる場合、その氏名		Full name of eighth joint inventor, if any
発明者の署名	日付	Signature Date
住所		Residence
国籍		Citizenship
郵便の宛先		Post Office Address

Docket No. _____ Armstrong, Kratz, Quintos, Hanson & Brooks, LLP

U.S. ASSIGNMENT

(Insert ASSIGNEE's Name(s) Address(es))

IN CONSIDERATION of the sum of One Dollar ($1.00), and of other good and valuable consideration paid to the undersigned inventor(s) (hereinafter ASSIGNOR) by **SIPEC CORPORATION, 7th Floor, Nissei Ohtsuka 3cho-me Bldg., 3-11-6, Ohtsuka, Bunkyo-ku, Tokyo 112-0012 Japan**

(hereinafter ASSIGNEE), the receipt of which is hereby acknowledged, the undersigned ASSIGNOR hereby sells, assigns and transfers to ASSIGNEE the entire and exclusive right, title and interest to the invention entitled:

(Title of Invention)

(*If the assignment is being filed after the filing of the application, this section must be completed)

for which application for Letters Patent of the United States was executed on even date herewith unless otherwise indicated below:

* filed on _____, Serial No. _____.

(**Armstrong, Kratz, Quintos, Hanson & Brooks, LLP** is hereby authorized to insert the serial code, serial number and/or filing date hereon, when known)

and all Letters Patent of the United States to be obtained therefor on said application or any continuation, divisional, substitute, reissue or reexamination thereof for the full term or terms for which the same may be granted.

The ASSIGNOR agrees to execute all papers necessary in connection with the application and any continuation, divisional, reissue or reexamination applications thereof and also to execute separate assignments in connection with such applications as the ASSIGNEE may deem necessary or expedient.

The ASSIGNOR agrees to execute all papers necessary in connection with any interference, litigation, or other legal proceeding which may be declared concerning this application or any continuation, divisional, reissue or reexamination thereof or Letters Patent or reissue patent issued thereon and to cooperate with the ASSIGNEE in every way possible in obtaining and producing evidence and proceeding with such interference, litigation, or other legal proceeding.

IN WITNESS WHEREOF, the undersigned inventor(s) has (have) affixed his/her/their signature(s).

(Signatures)

(Signature)	**Tamio ENDO** (Type Name)	(Date)
(Signature)	**Atsushi SATO** (Type Name)	(Date)
(Signature)	**Yasuhiko AMANO** (Type Name)	(Date)
(Signature)	**Tetsuji TAMURA** (Type Name)	(Date)
(Signature)	(Type Name)	(Date)
(Signature)	(Type Name)	(Date)
(Signature)	(Type Name)	(Date)

NO LEGALIZATION REQUIRED

DESCRIPTION

RESIST REMOVING APPARATUS AND METHOD OF REMOVING RESIST

Technical Field

The present invention relates to a resist removing apparatus and a method of removing a resist, which are indispensable in a lithography process for forming a microstructure such as a semiconductor integrated circuit.

Background Art

At present, as a method of removing a resist film, there are a method of removing a resist film by oxygen plasma ashing, a method of dissolving a resist film by heating by using an organic solvent (phenolic, halogenous or other organic solvent, 90°C to 130°C), and a heating and dissolving method using concentrated sulfuric acid/hydrogen peroxide. All of these methods need time, energy and chemical materials to decompose and dissolve the resist film, which becomes a burden on the lithography process. Though the demand for a new resist removing technique which replaces the removal by ashing and dissolving like this grows sharply, there are a small number of developments of the removal technique. A typical example of this is a new technique which develops a removing liquid and uses the removing action of a

high-frequency supersonic wave. As the removing liquid, the removing effect of, for example, "IPA-H_2O_2 component + salt such as fluoride" is recognized.

An object of the present invention is to provide a resist removing apparatus and a method of removing a resist which make it possible to form a liquid film on a resist and dissolve and remove the resist by using active oxygen generated in the liquid film, and achieve a breakaway from a resource and energy intensive type technique, namely, realization of an environmentally compatible type technique which does not depend on high energy and chemical solvents for removing a resist.

Summary of the Invention

A resist removing apparatus of the present invention includes a treatment chamber constituting a treatment space for removing a resist on a substrate, a substrate supporter supporting the substrate in the aforesaid treatment chamber and having a mechanism for moving the substrate in an upward and downward direction in the aforesaid treatment chamber and freely adjusting the treatment space, and a liquid film generator for forming a liquid film containing active oxygen on the resist of the substrate, and on forming the liquid film, the treatment space is adjusted by the moving mechanism of the aforesaid substrate supporter to control a state of the liquid film.

In one mode of the resist removing apparatus of the present invention, the aforesaid liquid film generator includes an ultraviolet rays emitting mechanism for emitting ultraviolet rays to the liquid film formed on the substrate.

In one mode of the resist removing apparatus of the present invention, wavelengths of the ultraviolet rays emitted from the ultraviolet rays emitting mechanism are 172 nm to 310 nm.

In one mode of the resist removing apparatus of the present invention, the ultraviolet rays emitting mechanism is a low pressure ultraviolet lamp.

In one mode of the resist removing apparatus of the present invention, a surface of the substrate and an upper surface portion of an inside of the aforesaid treatment chamber are brought into close vicinity to each other by the moving mechanism of the aforesaid substrate supporter, and the state of the liquid film is adjusted to a size to cover an approximately entire surface of the resist on the substrate.

In one mode of the resist removing apparatus of the present invention, a distance between the surface of the substrate and the upper surface portion of the inside of the treatment chamber is 1 mm or less.

In one mode of the resist removing apparatus of the present invention, the aforesaid liquid film generator includes an ozone supply mechanism for supplying ozone water to the liquid film.

In one mode of the resist removing apparatus of the present invention, the aforesaid liquid film generator includes peroxide water supply mechanism for supplying peroxide water to the liquid film.

In one mode of the resist removing apparatus of the present invention, the surface of the substrate and the upper surface portion of the inside of the aforesaid treatment chamber are separated from each other by the moving mechanism of the aforesaid substrate supporter, and the state of the liquid film is adjusted so that condensation forms on the resist surface on the substrate as liquid drops.

In one mode of the resist removing apparatus of the present invention, the aforesaid liquid film generator includes a mechanism for supplying mist-containing water vapor.

In one mode of the resist removing apparatus of the present invention, the aforesaid liquid film generator includes an ozone supply mechanism for supplying ozone gas to the mist-containing water vapor generated in the mist-containing water vapor supply mechanism to generate the active oxygen inside the liquid film formed on the substrate.

In one mode of the resist removing apparatus of the present invention, the aforesaid liquid film generator has a porous ceramic plate and supplies mist-containing water vapor from holes of the porous ceramic plate.

A method of removing a resist of the present

invention includes the steps of performing distance adjustment so that a substrate provided with a resist on a surface thereof and an upper surface portion of an inside of a treatment chamber constituting a treatment space for removing the resist are close to each other, forming a liquid film containing active oxygen to have film thickness restricted to the distance to cover an approximately entire surface of the resist on the substrate and dissolving and removing the resist by an action of the active oxygen.

In one mode of the method of removing the resist of the present invention, the distance between the surface of the substrate and the upper surface portion of the inside of the treatment chamber is adjusted to 1 mm or less.

In one mode of the method of removing the resist of the present invention, generation of the active oxygen is promoted in the liquid film by emitting ultraviolet rays to the liquid film.

In one mode of the method of removing the resist of the present invention, the active oxygen is generated in the liquid film by supplying ozone water to the liquid film.

In one mode of the method of removing the resist of the present invention, the active oxygen is generated in the liquid film by supplying peroxide water to the liquid film.

A method of removing a resist of the present invention includes the steps of performing distance

adjustment so that a substrate provided with a resist on a surface thereof and an upper surface portion of an inside of a treatment chamber constituting a treatment space for removing the resist are spaced from each other, supplying mist-containing water vapor containing active oxygen to allow liquid drops to form condensation on a surface of the resist, and dissolving and removing the resist by an action of the active oxygen.

In one mode of the method of removing the resist of the present invention, generation of the active oxygen is promoted in the liquid film by emitting ultraviolet rays to the liquid film.

In one mode of the method of removing the resist of the present invention, the active oxygen is generated in the liquid film by supplying ozone gas to the liquid film.

In one mode of the method of removing the resist of the present invention, the active oxygen is generated in the liquid film by supplying peroxide water to the liquid film.

Brief Description of the Drawings

Fig 1 is a schematic diagram showing a schematic constitution of a resist removing apparatus of a first embodiment;

Fig. 2 is a schematic diagram showing a substrate surface and its vicinity in the resist removing apparatus of the first embodiment;

Fig. 3 is a schematic diagram showing a state of a treatment chamber and its vicinity, which is a main constitution of a resist removing apparatus of a second embodiment; and

Fig. 4 is a schematic diagram showing a state of a treatment chamber and its vicinity, which is a main constitution of a resist removing apparatus of a modification example of the second embodiment.

Detailed Description of the Preferred Embodiments

Preferred embodiments to which the present invention is applied will be explained in detail with reference to the drawings, hereinafter.

-First Embodiment-

Fig. 1 is a schematic diagram showing a schematic constitution of a resist removing apparatus of a first embodiment.

This resist removing apparatus is for removing a resist formed on a substrate 10 such as a silicon wafer or a glass substrate in a lithography process, and is constructed by including a single sheet treatment chamber 1, which is a treatment chamber constructing a treatment space for removing the resist on the substrate 10, and which the substrate can be carried in and taken from, a substrate stage 2 which is provided in the treatment chamber 1 and on which the substrate 10 is supported and fixed, an ultraviolet ray transmission plate 3 provided on an upper surface portion of the treatment chamber 1 and

made of a synthetic quartz glass, a low pressure ultraviolet lamp 4 provided on an upper portion of the ultraviolet ray transmission plate 3 and emitting ultraviolet rays into the treatment chamber 1 via the ultraviolet ray transmission plate 3, a liquid film generator 5 for supplying ultra pure water and various kinds of chemical liquids via an inflow port 1a of the treatment chamber 1, and a liquid/gas discharger 6 for discharging a liquid and gas inside the treatment chamber 1 via an outlet port 1b of the treatment chamber 1.

The substrate stage 2 has a temperature regulating mechanism 2c for regulating the temperature of the substrate 10 placed thereon by hot water/cool water, and further has a rotating mechanism 2a for freely rotating the substrate 10 placed thereon and an upward and downward moving mechanism 2b for freely moving the substrate 10 placed as described above in the vertical direction, and at a time of removing a resist on the substrate 10, a surface of the substrate 10 and the ultraviolet ray transmission plate 3 are made closer to each other at a predetermined distance therebetween by the operation of the upward and downward moving mechanism 2b as will be described later.

The liquid film generator 5 is constructed by including an ultra pure water supply section 11 for supplying ultra pure water into the treatment chamber 1, an O_3 water supply section 12 for generating and

supplying ozone water (O_3 water), an H_2O_2 water supply section 13 for generating and supplying an aqueous solution of hydrogen peroxide (H_2O_2 water), and an O_2/N_2 gas supply section 14 for supplying an O_2/N_2 gas to the surface of the substrate 10 to facilitate ejection of the substrate 10 by removing the chemical liquid remaining on the surface of the substrate 10 after resist removing treatment.

The ultra pure water supply section 11 is constructed by including an ultra pure water tank 21 for storing ultra pure water supplied from outside, a level gauge 22 for measuring the level of the stored ultra pure water, a diaphragm pump 23 for accurately sucking and feeding out a predetermined amount of ultra pure water periodically, for example, and a flow meter 24 for measuring the amount of the ultra pure water fed out by the diaphragm pump 23.

The H_2O_2 water supply section 13 is constructed by including a pumping tank 25 for storing H_2O_2 water, an H_2O_2 supply line 26 for supplying H_2O_2 to the ultra pure water to generate H_2O_2 water, a pumping mechanism 27 for supplying N_2 into the pumping tank 25 to pump a predetermined amount of H_2O_2 water from the pumping tank 25, a level gauge 28 for measuring the level of the stored H_2O_2 water, and a flow control valve 29 for controlling an amount of H_2O_2 water which is fed out.

The O_2/N_2 gas supply section 14 forms passages for O_2 gas and N_2 gas respectively, and is provided with a passage for a mixture gas of both of them, and each

of the passages for the O_2 gas and the N_2 gas is provided with a pressure regulator 31 and a mass flow controller 32 for regulating the flow of the gas.

The liquid/gas discharger 6 has a gas-liquid separating mechanism 33, and the discharged liquid and the discharged gas are separated by the operation of this liquid-gas separating mechanism 33.

In order to remove the resist on the substrate 10 by using this resist removing apparatus, a distance between the surface of the substrate 10 and the ultraviolet ray transmission plate 3 is adjusted to a predetermined distance by the upward and downward moving mechanism 2b of the substrate stage 2. As this distance, 0.1 mm to 1mm is preferable in consideration that the distance should be within the range in which the ultraviolet rays emitted as will be described later are not attenuated.

While the substrate 10 is being rotated by the rotating mechanism 2a of the substrate stage 2 in this state, O_3 water is supplied into the treatment space formed between the surface of the substrate 10 of the treatment chamber 1 and the ultraviolet ray transmission plate 3 from the O_3 water supply section 12. Thereby, the treatment space is filled with the O_3 water, and a liquid film 41, which is formed to have the film thickness restricted within a thin film state of the distance (0.1 mm to 1 mm) of the surface of the substrate 10 and the ultraviolet ray transmission plate 3 and covers an approximately

entire surface of a resist 42 on the substrate 10, is formed, as shown in Fig. 2.

In the O_3 water of the liquid film 41, as a result of dissolution of O_3 into aqueous solution, O_3 is decomposed by the reaction of OH^- and O_3, and various kinds of active oxygen such as HO_2, O_2^-, and OH are generated, as shown in the following series of (Formula 1).

(Formula 1):

$$O_3 + OH^- \rightarrow HO_2 + O_2^-$$

$$O_3 + HO_2 \rightarrow 2O_2 + OH$$

$$O_3 + OH \rightarrow O_2 + HO_2$$

$$2HO_2 \rightarrow O_3 + H_2O$$

$$HO_2 + OH \rightarrow O_2 + H_2O$$

Accordingly, in addition to the direct oxidation by O_3, radical oxidation by active oxygen such as O_2^-, HO_2 and OH, which are secondarily generated, advances in the aqueous water (in this case, selectivity other than O_3 reduces, but oxidation is intense).

Subsequently, in the state in which the liquid film 41 is formed, ultraviolet rays are uniformly emitted to the liquid film 41 by the ultraviolet lamp 4. At this time, O_3 is decomposed by the ultraviolet rays, and by the reaction of excited oxygen atoms generated thereby and molecules of water, generation of hydroxy radical (OH) is promoted, as shown in the following series of (Formula 2). In this case, as the wavelength of the ultraviolet rays which are emitted, it is required to be 310 nm or less to

decompose O_3, and 50% transmission distance of the ultraviolet rays with the wavelength of 172 nm with respect to air is 3.1 mm from the optical absorption sectional area of oxygen (0.259×10^{-18} the number of molecules / cm2), but since it is difficult to make the apparatus with the 50% transmission distance of 3.1 mm or less, it is preferable to use the ultraviolet rays with the wavelength of 172 nm to 310 nm. In this embodiment, the ultraviolet rays with the comparatively short wavelength of around 184.9 nm are adopted. Here, the ultraviolet rays are used to generate O_3 in the aqueous water and cause the reaction to decompose the generated O_3, and therefore their wavelengths may be in the comparatively wide range as described above.

(Formula 2):

$$O_3 + h\nu(\lambda<310\ nm) \rightarrow O(^1D) + O_2(a^1\Delta P)$$

$$H_2O + O(^1D) \rightarrow 2OH$$

$$OH + O_3 \rightarrow O_2 + HO_2$$

$$HO_2 + O_3 \rightarrow 2O_2 + OH$$

As described above, the resist that is an organic substance is decomposed into H_2O/CO_2 by the activating action, which various kinds of active oxygen generated in the liquid film 41 as described above have, and dissolved and removed.

At the time of generating the liquid film 41, H_2O_2 water may be supplied from the H_2O_2 water supply section 13 in place of the O_3 water, or with the O_3 water. In this case, as shown in the following

series of (Formula 3), H_2O_2 reacts with O_3, and thereby the generation of the hydroxy radical (OH) is promoted.

(Formula 3):

$$H_2O_2 \rightarrow H + HO_2^-$$

$$HO_2^- + O_3 \rightarrow OH + O_2^- + O_2$$

Further, by emitting the aforesaid ultraviolet rays to the liquid film 41 containing H_2O_2 water, H_2O_2 is directly decomposed, and generation of hydroxy radical (OH) is further promoted, as shown in the following (Formula 4).

(Formula 4):

$$H_2O_2 + h\nu(\lambda<310\ nm) \rightarrow 2OH$$

As described thus far, according to this embodiment, it is made possible to form the liquid film 41 on the resist on the substrate 1, and dissolve and remove the resist by using various kinds of active oxygen generated in the liquid film 41, and a breakaway from a resource and energy-intensive technique, namely, realization of an environmentally compatible technique which does not depend on high energy and chemical solvents for removing a resist can be achieved.

-Second Embodiment-

In this embodiment, a resist removing apparatus including a treatment chamber and a substrate stage which are constructed approximately similarly to the first embodiment is disclosed, but this embodiment differs from the first embodiment in the point that

the state of the supplied liquid film on the resist is different. The common components and the like to the first embodiment are given the same reference numerals and symbols, and the explanation thereof will be omitted.

Fig. 3 is a schematic diagram showing a state of the treatment chamber and its vicinity, which is a main constitution of the resist apparatus of the second embodiment.

This resist removing apparatus is constructed by including a treatment chamber 1 provided with an ultraviolet ray transmission plate 3, an ultraviolet lamp 4 and the like similarly to the resist removing apparatus of the first embodiment, a substrate stage 2 having an upward and downward moving mechanism 2b, a liquid film generator 51, liquid/gas discharger (not shown: the same as the liquid/gas discharger 6) which performs liquid discharge and gas discharge inside the treatment chamber 1 via an outlet port of the treatment chamber 1.

Here, the liquid film generator 51 is constructed by including a vapor supply section 52 for supplying water vapor into the treatment chamber 1, and an O_3 gas supply section (ozonizer) 53 for supplying O_3 gas of high concentration into the treatment chamber 1.

In order to remove the resist on a substrate 10 by using this resist removing apparatus, a distance between a surface of the substrate 10 and the ultraviolet ray transmission plate 3 is initially

adjusted to a predetermined distance by the upward and downward moving mechanism 2b of the substrate stage 2. In this embodiment, the distance is made longer as compared with the first embodiment (10 mm to 30 mm). Here, the temperature in the treatment chamber 1 is adjusted to 80°C to 90°C, and the substrate temperature is adjusted to room temperature to 60°C.

While the substrate 10 is being rotated by the rotating mechanism 2a of the substrate stage 2 in this state, vapor is supplied from the vapor supply section 52 and O_3 gas is supplied from the O_3 gas supply section 53, respectively into the treatment space formed between the front surface of the substrate 10 of the treatment chamber 1 and the ultraviolet ray transmission plate 3. At this time, the aforesaid vapor is the vapor containing mist, and the inside of the treatment chamber 1 is in the atmosphere of the mixture of mist-containing vapor in a saturated vapor state and O_3 gas. The mist-containing vapor is the mixture of the mist of a grain size of 10 μm to 50 μm and vapor. Since the mist has a large surface area due to its approximately spherical shape and hence O_3 gas easily penetrates into it, the O_3 gas can be sufficiently supplied by using this mist-containing vapor.

Due to the aforesaid saturated mixture atmosphere in addition to the temperature difference between the temperature of the treatment camber 1 and the

substrate temperature, liquid drops form condensation on the resist of the substrate 10 as a number of microscopic thin liquid films 61 into which O_3 gas is dissolved. At this time, in the liquid film 61, the series of reactions of (Formula 1) explained in the first embodiment are caused, O_3 is decomposed by the reaction of OH^- and O_3 by dissolution of O_3 into aqueous water, and various kinds of active oxygen such as HO_2, O_2^- and OH are generated.

Accordingly, in the aqueous water, radical oxidation by the active oxygen such as O_2^-, HO_2 and OH, which are secondarily generated, advances in addition to the direct oxidation by O_3.

Subsequently, in the state in which the liquid films 61 are formed, ultraviolet rays are uniformly emitted to the liquid films 61 by the ultraviolet lamp 4 under the same conditions as in the first embodiment. At this time, the series of reactions of (Formula 2) explained in the first embodiment is caused, O_3 is decomposed by the ultraviolet rays, and by the reaction of the excited oxygen atoms generated by this and molecules of water, generation of hydroxy radical (OH) is promoted.

By the activating action, which various kinds of active oxygen generated in the liquid films 61 as described above have, the resist that is an organic substance is decomposed into H_2O and CO_2, and dissolved and removed.

As explained thus far, according to this

embodiment, it is made possible to form the liquid films 61 on the resist on the substrate 10, and dissolve and remove the resist by using various kinds of active oxygen generated in the liquid films 61 (especially, in their surface layers), and a breakaway from the resource and energy-intensive technology, namely, realization of an environmentally compatible technology that does not depend on high energy or chemical solvents for removing a resist can be achieved.

-Modification Example-

Here, a modification example of the second embodiment will be explained.

In this modification example, a resist removing apparatus constructed approximately similarly to the second embodiment is disclosed, but the modification example differs in the point that a porous ceramic plate is provided in place of the ultraviolet lamp.

Fig. 4 is a schematic diagram showing a state of a treatment chamber and its vicinity, which is a main constitution of the resist removing apparatus of this modification example.

This resist removing apparatus is constructed by including a treatment chamber 1 similar to the resist removing apparatus of the first embodiment, a porous ceramic plate 71 provided in place of the ultraviolet lamp, a substrate stage 2 having an upward and downward moving mechanism 2b, a high concentration O_3 gas supply section 53, and a liquid/gas discharger

(not shown: the same as the liquid/gas discharger 6) which performs liquid discharge and gas discharge inside the treatment chamber 1 via an outlet port of the treatment chamber 1.

The porous ceramic plate 71 is constructed so that mist-containing water vapor containing uniform mists of a small grain size and mist-containing water vapor containing O_3 gas are supplied to the substrate 10 via holes 72.

In order to remove the resist on the substrate 10 by using this resist removing apparatus, the distance between the front surface of the substrate 10 and the porous ceramic plate 71 is firstly adjusted to a predetermined distance by the upward and downward moving mechanism 2b of the substrate stage 2. In this example, the distance is made longer (10 mm to 30 mm) as compared with the first embodiment. Here, the temperature inside the treatment chamber 1 is adjusted to 80°C to 90°C, and the substrate temperature is adjusted to room temperature to 60°C.

While the substrate 10 is being rotated by the rotating mechanism 2a of the substrate stage 2 in this state, vapor is supplied from the holes 72 of the porous ceramic plate 71, and O_3 gas is supplied from the high concentration O_3 gas supply section 53, respectively into the treatment space formed between the surface of the substrate 10 of the treatment chamber 1 and the porous ceramic plate 71. At this time, the aforesaid vapor is mist-containing water

vapor, the inside of the treatment chamber 1 is in the atmosphere of the mixture of the mist-containing water vapor in a saturated vapor state and O_3 gas, and O_3 gas is dissolved into the mist-containing water vapor.

Due to the aforesaid saturated mixture atmosphere in addition to the temperature difference between the temperature of the inside of the treatment chamber 1 and the substrate temperature, the liquid drops form condensation on the resist of the substrate 10 as a number of microscopic thin liquid films 61.

Accordingly, in the aqueous solution, radical oxidation by the active oxygen such as O_2^-, HO_2 and OH, which are secondarily generated, advances in addition to the direct oxidation by O_3.

By the activating action, which various kinds of active oxygen generated in the liquid films as described above have, the resist that is an organic substance is decomposed into H_2O and CO_2, and dissolved and removed.

As explained thus far, according to this modification example, the liquid drops into which O_3 is dissolved form condensation to form the liquid films on the resist, whereby it is made possible to dissolve and remove the resist by using various kinds of active oxygen, and it is possible to achieve a breakaway from the resource and energy-intensive technology, namely, realization of an environmentally compatible technology that does not depend on high

energy or chemical solvents for removing a resist.

Industrial Applicability

According to the present invention, it is made possible to form the liquid films on the resist and dissolve and remove the resist by using active oxygen generated in the liquid films to thereby enable a breakaway from resource and energy-intensive technology, namely, realization of an environmentally compatible technology that does not depend on high energy or chemical solvents for removing a resist.

CLAIMS

What is claimed is:

1. A resist removing apparatus, comprising:

a treatment chamber constituting a treatment space for removing a resist on a substrate;

a substrate supporter supporting the substrate in said treatment chamber and having a mechanism for moving the substrate in an upward and downward direction in said treatment chamber and freely adjusting the treatment space; and

a liquid film generator for forming a liquid film containing active oxygen on the resist of the substrate,

wherein on forming the liquid film, the treatment space is adjusted by the moving mechanism of said substrate supporter to control a state of the liquid film.

2. The resist removing apparatus according to claim 1, wherein said liquid film generator includes an ultraviolet ray emitting mechanism for emitting ultraviolet rays to the liquid film formed on the substrate.

3. The resist removing apparatus according to claim 2, wherein wavelengths of the ultraviolet rays emitted from the ultraviolet ray emitting mechanism are 172 nm to 310 nm.

4. The resist removing apparatus according to claim 2, wherein the ultraviolet ray emitting

mechanism is a low pressure ultraviolet lamp.

5. The resist removing apparatus according to claim 2, wherein a surface of the substrate and an upper surface portion of an inside of said treatment chamber are brought into close vicinity to each other by the moving mechanism of said substrate supporter, and the state of the liquid film is adjusted to a size to cover an approximately entire surface of the resist on the substrate.

6. The resist removing apparatus according to claim 5, wherein a distance between the surface of the substrate and the upper surface portion of the inside of said treatment chamber is 1 mm or less.

7. The resist removing apparatus according to claim 6, wherein said liquid film generator includes an ozone supply mechanism for supplying ozone water to the liquid film.

8. The resist removing apparatus according to claim 6, wherein said liquid film generator includes a peroxide water supply mechanism for supplying peroxide water to the liquid film.

9. The resist removing apparatus according to claim 2, wherein the surface of the substrate and the upper surface portion of the inside of said treatment chamber are separated from each other by the moving mechanism of said substrate supporter, and the state of the liquid film is adjusted so that condensation forms on the resist surface on the substrate as liquid drops.

10. The resist removing apparatus according to claim 9, wherein said liquid film generator includes a mechanism for supplying mist containing water vapor.

11. The resist removing apparatus according to claim 10, wherein said liquid film generator includes an ozone supply mechanism for supplying ozone gas to the mist containing water vapor generated in the mist containing water vapor supply mechanism to generate the active oxygen inside the liquid film formed on the substrate.

12. The resist removing apparatus according to claim 1, wherein said liquid film generator has a porous ceramic plate and supplies mist containing water vapor from holes of the porous ceramic plate.

13. A method of removing a resist, comprising the steps of:

performing distance adjustment so that a substrate provided with a resist on a surface and an upper surface portion of an inside of a treatment chamber constituting a treatment space for removing the resist are close to each other;

forming a liquid film containing active oxygen to have film thickness restricted to the distance to cover an approximately entire surface of the resist on the substrate;, and

dissolving and removing the resist by an action of the active oxygen.

14. The method of removing the resist according to claim 13, wherein the distance between the surface

of the substrate and the upper surface portion of the inside of the treatment chamber is adjusted to 1 mm or less.

15. The method of removing the resist according to claim 13, wherein generation of the active oxygen is promoted in the liquid film by emitting ultraviolet rays to the liquid film.

16. The method of removing the resist according to claim 13, wherein the active oxygen is generated in the liquid film by supplying ozone water to the liquid film.

17. The method of removing the resist according to claim 13, wherein the active oxygen is generated in the liquid film by supplying peroxide water to the liquid film.

18. A method of removing a resist, comprising the steps of:

performing distance adjustment so that a substrate provided with a resist on a surface and an upper surface portion of an inside of a treatment chamber constituting a treatment space for removing the resist are spaced from each other;

supplying mist containing water vapor containing active oxygen to allow liquid drops to form condensation on a surface of the resist; and

dissolving and removing the resist by an action of the active oxygen.

19. The method of removing the resist according to claim 18, wherein generation of the active oxygen

is promoted in the liquid film by emitting ultraviolet rays to the liquid film.

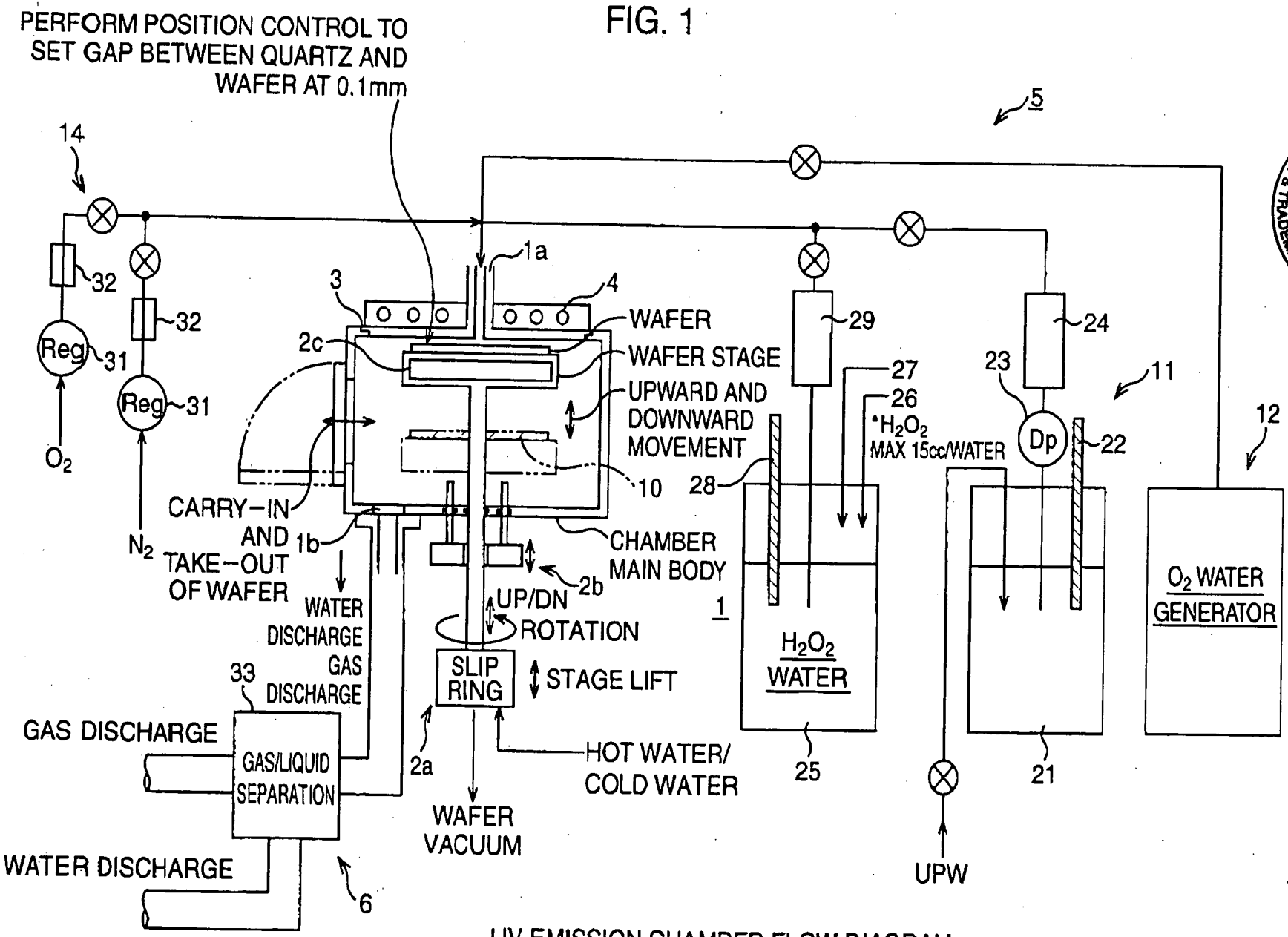
20. The method of removing the resist according to claim 18, wherein the active oxygen is generated in the liquid film by supplying ozone gas to the liquid film.

21. The method of removing the resist according to claim 18, wherein the active oxygen is generated in the liquid film by supplying peroxide water to the liquid film.

ABSTRACT

In a resist removing apparatus of the present invention, a distance between a surface of a substrate (10) and an ultraviolet rays transmission plate (3) is adjusted to a predetermined distance by an upward and downward moving mechanism (2b) of a substrate stage (2), and O_3 water is supplied from an O_3 water supply section (12) to a treatment space formed between the surface of the substrate (10) and the ultraviolet ray transmission plate (3) to form a liquid film (41). Various kinds of active oxygen are generated by emitting ultraviolet rays of wavelengths of 172 nm to 310 nm to the liquid film (41) by an ultraviolet lamp, and dissolving O_3, and thereby the resist is dissolved and removed. This construction makes it possible to form the liquid film on the resist and dissolve and remove the resist by using the active oxygen generated in the liquid film, and achieve a breakaway from the resources and energy-intensive technique, namely, realization of an environmentally compatible technique which does not depend on high energy and chemical solvents for removing a resist.

FIG. 1



UV EMISSION CHAMBER FLOW DIAGRAM

FIG. 2

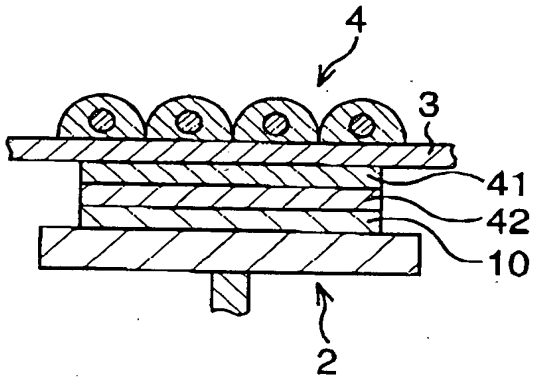

4
3
41
42
10
2

FIG. 3

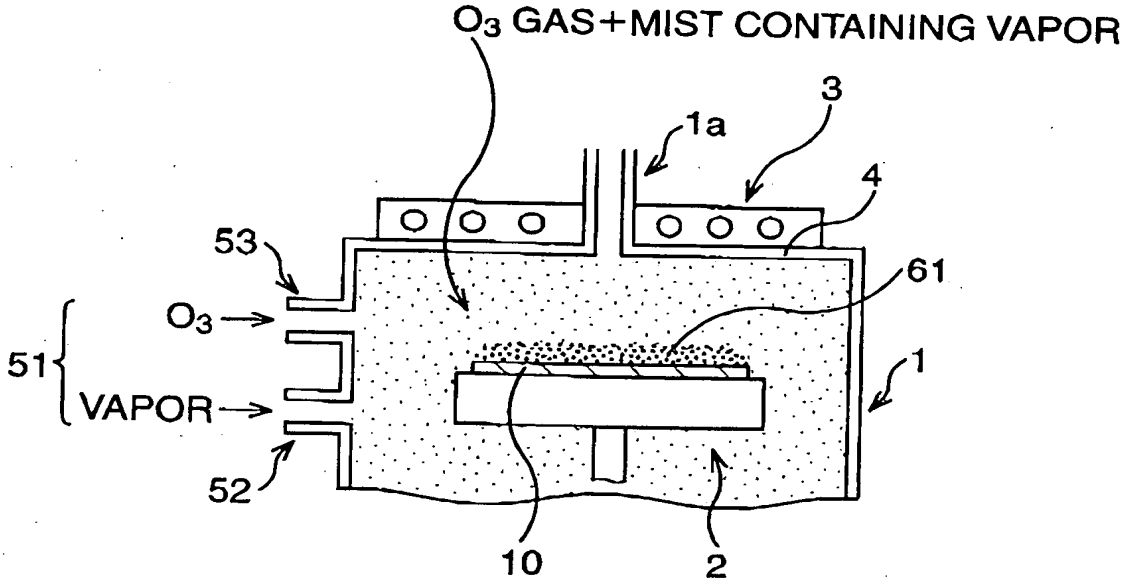
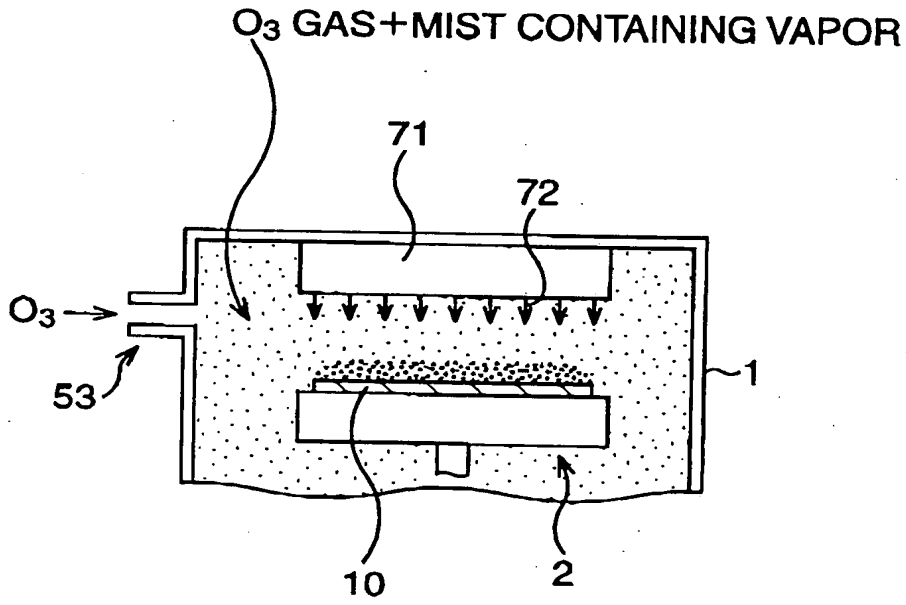

O3 GAS+MIST CONTAINING VAPOR
3
1a
4
53
61
O3
51
VAPOR
1
52
10
2

FIG. 4



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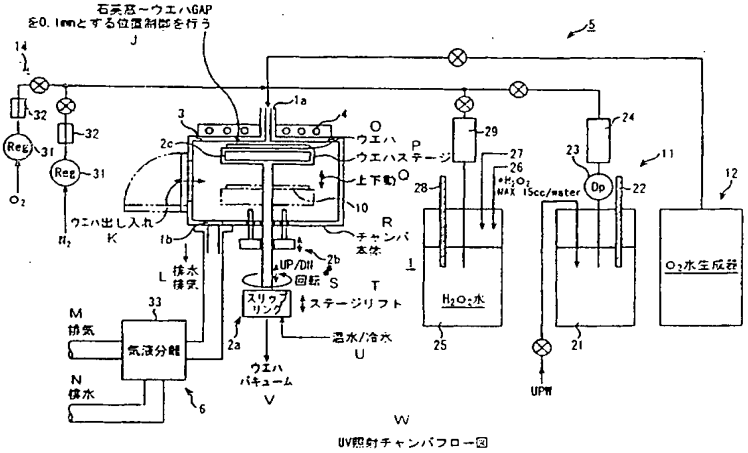
(54) Title: RESIST REMOVING APPARATUS AND METHOD OF REMOVING RESIST

(54) 発明の名称: レジスト除去装置及びレジスト除去方法



UV照射チャンバフロー図

J ..POSITION CONTROL SUCH THAT GAP BETWEEN QUARTZ WINDOW AND WAFER IS SET FOR 0.1mm CONDUCTED
K...WAFER INSERTION AND TAKE-OUT
L ..WATER DISCHARGE/GAS DISCHARGE
M...GAS DISCHARGE
N...WATER DISCHARGE
O...WAFER
P...WAFER STAGE
Q...VERTICAL MOVEMENT
R CHAMBER MAIN BODY
S...ROTATION
T ..STAGE LIFT
U. .HOT WATER/COLD WATER
V...WAFER VACUUM
W...UV IRRADIATION CHAMBER FLOW DIAGRAM
2A...SLIP RING
12...O_2 WATER GENERATOR
25...H_2O_2 WATER
33...GAS/LIQUID SEPARATION

(57) Abstract: A resist removing apparatus wherein the spacing between ultraviolet transmission plate (3) and a surface of substrate (10) is regulated at given distance by means of downward moving means (2b) of substrate stage (2) and wherein O_3 water from O_3 water supply section (12) is fed into a treating space provided between ultraviolet transmission plate (3) and surface of substrate (10) of treatment chamber (1) so as to form liquid film (41). This liquid film (41) is irradiated with ultraviolet rays of 172 to 310 nm wavelength emitted from an ultraviolet lamp so that the O_3 is

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明　細　書

レジスト除去装置及びレジスト除去方法

技術分野

本発明は、半導体集積回路等の微細構造形成のためのリソグラフィー工程において不可欠であるレジスト除去装置及びレジスト除去方法に関する。

背景技術

現在、レジスト膜を除去する手法としては、酸素プラズマによりレジスト膜を灰化除去する方法と、有機溶媒（フェノール系・ハロゲン系など有機溶媒、９０℃～１３０℃）を用いてレジスト膜を加熱溶解させる方法、または濃硫酸・過酸化水素を用いる加熱溶解法がある。これら何れの手法も、レジスト膜を分解し溶解するための時間、エネルギー及び化学材料が必要であり、リソグラフィー工程の負担となっている。このような灰化や溶解による除去に替わる新しいレジスト除去技術への要求は大きいが、剥離技術の開発は未だ数少ない。その代表例は、剥離液を開発し高周波超音波の剥離作用を用いる新技術である。剥離液として例えば「ＩＰＡ－H_2O_2成分系＋フッ化物などの塩類」の剥離効果が認められている。

本発明の目的は、レジストに液膜を形成し、液膜内で発生する活性酸素を利用してレジストを溶解除去することを可能とし、資源・エネルギー多消費型技術からの脱却、即ちレジストの除去に高エネルギーや化学溶剤に依存しない環境共生型技術を実現するレジスト除去装置及びレジスト除去方法を提供することである。

発明の開示

本発明のレジスト除去装置は、基板上のレジストを除去するための処理空間を構成する処理室と、前記処理室内で前記基板を支持し、前記処理室内で前記基板を上下方向に移動せしめ、前記処理空間を自在に調節する機構を有する基板支持手段と、前記基板の前記レジスト上に活性酸素を含む液膜を形成する液膜生成手

本発明のレジスト除去装置の一態様では、前記液膜生成手段は、ミスト含有水蒸気を供給する機構を含む。

本発明のレジスト除去装置の一態様では、前記液膜生成手段は、前記ミスト含有水蒸気供給機構で生成されたミスト含有水蒸気にオゾンガスを供給し、前記基板上に形成される前記液膜内に前記活性酸素を発生せしめるオゾン供給機構を含む。

本発明のレジスト除去装置の一態様では、前記液膜生成手段は、多孔質セラミック板を有しており、前記多孔質セラミック板の空孔からミスト含有水蒸気を供給するものである。

本発明のレジスト除去方法は、表面にレジストが設けられた基板と、前記レジストを除去するための処理空間を構成する処理室内の上面部とが近接するように距離調節し、前記基板上の前記レジストの略全面を覆うように、活性酸素を含む液膜を前記距離に規制された膜厚となるように形成し、前記活性酸素の作用により前記レジストを溶解除去する。

本発明のレジスト除去方法の一態様では、前記基板表面と前記処理室内の上面部との前記距離を１ｍｍ以下に調節する。

本発明のレジスト除去方法の一態様では、前記液膜に紫外線を照射することにより、前記液膜内に前記活性酸素の発生を促進せしめる。

本発明のレジスト除去方法の一態様では、前記液膜にオゾン水を供給することにより、前記液膜内に前記活性酸素を発生せしめる。

本発明のレジスト除去方法の一態様では、前記液膜に過酸化水素水を供給することにより、前記液膜内に前記活性酸素を発生せしめる。

説明する。

（第１の実施例）

図１は、第１の実施例のレジスト除去装置の概略構成を示す模式図である。

このレジスト除去装置は、リソグラフィー工程においてシリコンウェーハやガラス基板等の基板１０上に形成されたレジストを除去するためのものであり、基板１０上のレジストを除去するための処理空間を構成する処理室であり、基板出し入れ自在とされてなる枚葉式の処理チャンバー１と、処理チャンバー１内に設けられ、基板１０が支持固定される基板ステージ２と、処理チャンバー１の上面部に設けられ、合成石英ガラスからなる紫外線透過板３と、紫外線透過板３の上部に設けられ、紫外線透過板３を介して処理チャンバー１内に紫外線を照射する低圧の紫外線ランプ４と、処理チャンバー１の流入口１ａを介して超純水及び各種薬液を供給する液膜生成手段５と、処理チャンバー１の流出口１ｂを介して処理チャンバー１内の排液及び排気を行う排液・排気手段６とを備えて構成されている。

基板ステージ２は、設置された基板１０の温度を温水／冷水により調節する温度調節機構２ｃを有し、更には、設置された基板１０を自在に回転させる回転機構２ａとともに、上述のように設置された基板１０を上下方向に自在に移動せしめる上下移動機構２ｂを有しており、基板１０上のレジスト除去時には、後述するように上下移動機構２ｂの作動により基板１０表面と紫外線透過板３とを所定距離に近接させる。

液膜生成手段５は、処理チャンバー１内に超純水を供給するための超純水供給部１１と、オゾン水（O_3水）水を生成して供給するためのO_3水供給部１２と、過酸化水素水の水溶液（H_2O_2水）を生成して供給するためのH_2O_2水供給部１３と、レジスト除去処理の後に基板１０表面に残存する薬液を除去して基板１０の取り出しを容易にするため、基板１０表面にO_2／N_2ガスを供給するO_2／N_2ガス供給部１４とを備えて構成されている。

３との間に形成される処理空間に供給する。これにより、図２に示すように、当該処理空間をO_3水で満たし、基板１０表面と紫外線透過板３との距離（０．１ｍｍ～１ｍｍ）の薄膜状態に膜厚が規制されてなり、基板１０上のレジスト４２の略全面を覆う液膜４１が形成される。

液膜４１のO_3水中では、O_3の水溶液への溶解により、以下の一連の（式１）に示すように、OH^-とO_3との反応によりO_3が分解し、HO_2、O_2^-、ＯＨ等の種々の活性酸素が発生する。

（式１）：

$O_3+OH^- \rightarrow HO_2+O_2^-$

$O_3+HO_2 \rightarrow 2O_2+OH$

$O_3+OH \rightarrow O_2+HO_2$

$2HO_2 \rightarrow O_3+H_2O$

$HO_2+OH \rightarrow O_2+H_2O$

従って、水溶液中では、O_3による直接酸化の他、副生成したO_2^-，HO_2，ＯＨ等の活性酸素によるラジカル的酸化が進行することになる（この場合、O_3以外の選択性は低下するが、酸化は強力である。）。

そして、液膜４１が形成された状態で、紫外線ランプ４により当該液膜４１に紫外線を均一に照射する。このとき、以下の一連の（式２）に示すように、O_3が紫外線により分解し、これにより生じた励起酸素原子と水分子の反応によりヒドロキシラジカル（ＯＨ）の生成が助長される。この場合、照射する紫外線の波長としては、O_3を分解するためには３１０ｎｍ以下であることを要し、また、波長が１７２ｎｍの紫外線の空気に対する５０％透過距離が、酸素の光吸収断面積（０．２５９×10^{-18}分子数／cm^2）から３．１ｍｍとなるが、５０％透過距離が３．１ｍｍ以下では装置化が困難であることから、１７２ｎｍ～３１０ｎｍのものを用いることが好ましい。本実施例では比較的短い１８４．９ｎｍ付近を採

以上説明したように、本実施例によれば、基板１上のレジストに液膜４１を形成し、液膜４１内で発生する各種の活性酸素を利用してレジストを溶解除去することを可能とし、資源・エネルギー多消費型技術からの脱却、即ちレジストの除去に高エネルギーや化学溶剤に依存しない環境共生型技術を実現することができる。

（第２の実施例）

本実施例では、第１の実施例と略同様に構成された処理チャンバー及び基板ステージを備えたレジスト除去装置を開示するが、レジスト上の供給される液膜の状態が異なる点で相違する。なお、第１の実施例と共通する構成部材等については同符号を記して説明を省略する。

図３は、第２の実施例のレジスト除去装置の主要構成である処理チャンバー近傍の様子を示す模式図である。

このレジスト除去装置は、第１の実施例のレジスト除去装置と同様に紫外線透過板３や紫外線ランプ４等が設けられた処理チャンバー１と、上下移動機構２ｂを有する基板ステージ２と、液膜生成手段５１と、処理チャンバー１の流出口を介して処理チャンバー１内の排液及び排気を行う排液・排気手段（不図示：排液・排気手段６と同様）を備えて構成されている。

ここで、液膜生成手段５１は、処理チャンバー１内に水蒸気を供給する蒸気供給部５２と、処理チャンバー１内に高濃度のO_3ガスを供給するO_3ガス供給部（オゾナイザー）５３とを備えて構成されている。

このレジスト除去装置を用いて基板１０上のレジストを除去するには、先ず、基板ステージ２の下移動機構２ｂにより、基板１０表面と紫外線透過板３との距離を所定距離に調節する。本実施例では、この距離を第１の実施例に比して離間（１０ｍｍ～３０ｍｍ）させる。ここで、処理チャンバー１内の温度を８０℃～９０℃、基板温度を常温～６０℃に調節する。

以上説明したように、本実施例によれば、基板１上のレジストに液膜６１を形成し、液膜６１内（特にその表層）で発生する各種の活性酸素を利用してレジストを溶解除去することを可能とし、資源・エネルギー多消費型技術からの脱却、即ちレジストの除去に高エネルギーや化学溶剤に依存しない環境共生型技術を実現することができる。

－変形例－

ここで、第２の実施例の変形例について説明する。

この変形例では、第２の実施例と略同様に構成されたレジスト除去装置を開示するが、紫外線ランプの替わりに多孔質セラミック板が設けられている点で相違する。

図４は、本変形例のレジスト除去装置の主要構成である処理チャンバー近傍の様子を示す模式図である。

このレジスト除去装置は、第１の実施例のレジスト除去装置と同様の処理チャンバー１と、紫外線ランプの替わりに設けられた多孔質セラミック板７１と、上下移動機構２ｂを有する基板ステージ２と、高濃度のO_3ガス供給部５３と、処理チャンバー１の流出口を介して処理チャンバー１内の排液及び排気を行う排液・排気手段（不図示：排液・排気手段６と同様）を備えて構成されている。

多孔質セラミック板７１は、その空孔７２を介して、小粒径の均一なミストを含むミスト含有水蒸気や更にO_3ガスを含むミスト含有水蒸気が基板１０に供給されるように構成されている。

このレジスト除去装置を用いて基板１０上のレジストを除去するには、先ず、基板ステージ２の下移動機構２ｂにより、基板１０表面と多孔質セラミック板７１との距離を所定距離に調節する。本実施例では、この距離を第１の実施例に比して離間（１０ｍｍ～３０ｍｍ）させる。ここで、処理チャンバー１内の温度を８０℃～９０℃、基板温度を常温～６０℃に調節する。

請　求　の　範　囲

１．基板上のレジストを除去するための処理空間を構成する処理室と、

前記処理室内で前記基板を支持し、前記処理室内で前記基板を上下方向に移動せしめ、前記処理空間を自在に調節する機構を有する基板支持手段と、

前記基板の前記レジスト上に活性酸素を含む液膜を形成する液膜生成手段と

を含み、

前記液膜を形成するに際して、前記基板支持手段の前記移動機構により前記処理空間を調節し、前記液膜の状態を制御することを特徴とするレジスト除去装置。

２．前記液膜生成手段は、前記基板上に形成された前記液膜に紫外線を照射する紫外線照射機構を含むことを特徴とする請求項１に記載のレジスト除去装置。

３．前記紫外線照射手段から照射する紫外線の波長が１７２ｎｍ～３１０ｎｍであることを特徴とする請求項２に記載のレジスト除去装置。

４．前記紫外線照射手段が低圧紫外線ランプであることを特徴とする請求項２に記載のレジスト除去装置。

５．前記基板支持手段の前記移動機構により前記基板表面と前記処理室内の上面部とを近接させ、前記液膜の状態を前記基板上の前記レジストの略全面を覆うサイズに調節することを特徴とする請求項２に記載のレジスト除去装置。

６．前記基板表面と前記処理室内の上面部との距離が１ｍｍ以下であることを特徴とする請求項５に記載のレジスト除去装置。

７．前記液膜生成手段は、前記液膜にオゾン水を供給するオゾン供給機構を含むことを特徴とする請求項６に記載のレジスト除去装置。

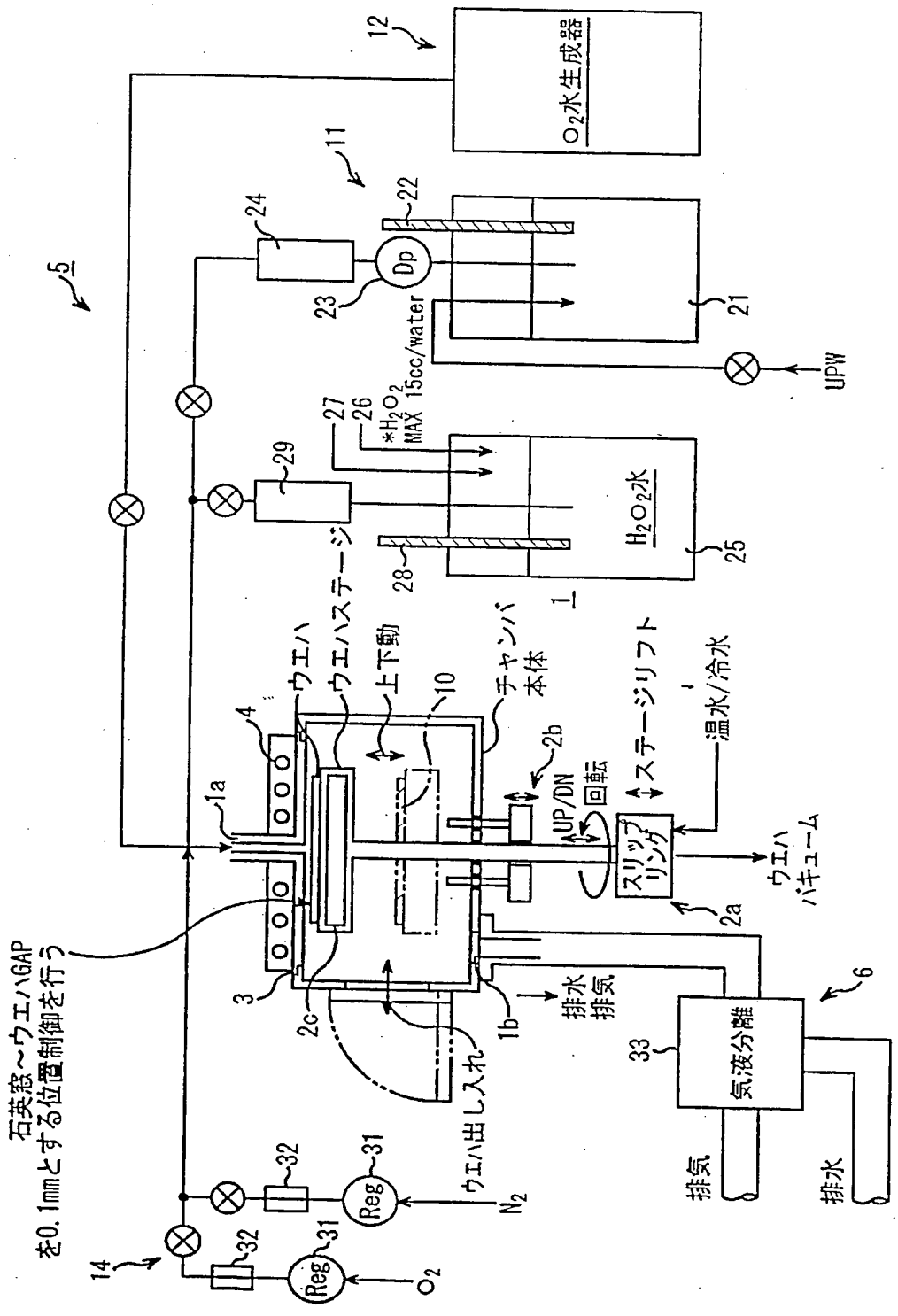
８．前記液膜生成手段は、前記液膜に過酸化水素水を供給する過酸化水素水供給機構を含むことを特徴とする請求項６に記載のレジスト除去装置。

９．前記基板支持手段の前記移動機構により前記基板表面と前記処理室内の上面部とを離間させ、前記液膜の状態を前記基板上の前記レジスト表面で液滴として結露するように調節することを特徴とする請求項２に記載のレジスト除去装置。

１０．前記液膜生成手段は、ミスト含有水蒸気を供給する機構を含むことを特徴とする請求項９に記載のレジスト除去装置。

２１．前記液膜に過酸化水素水を供給することにより、前記液膜内に前記活性酸素を発生せしめることを特徴とする請求項１８に記載のレジスト除去方法。

図 1



UV照射チャンバフロー図

図２

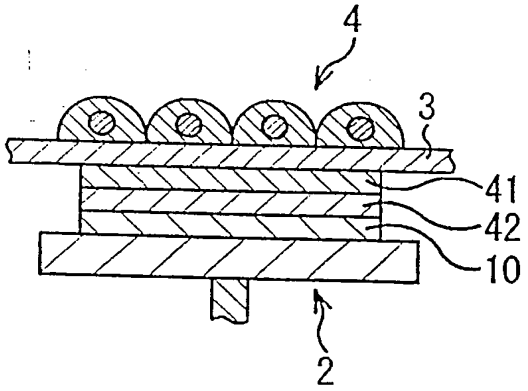


図３

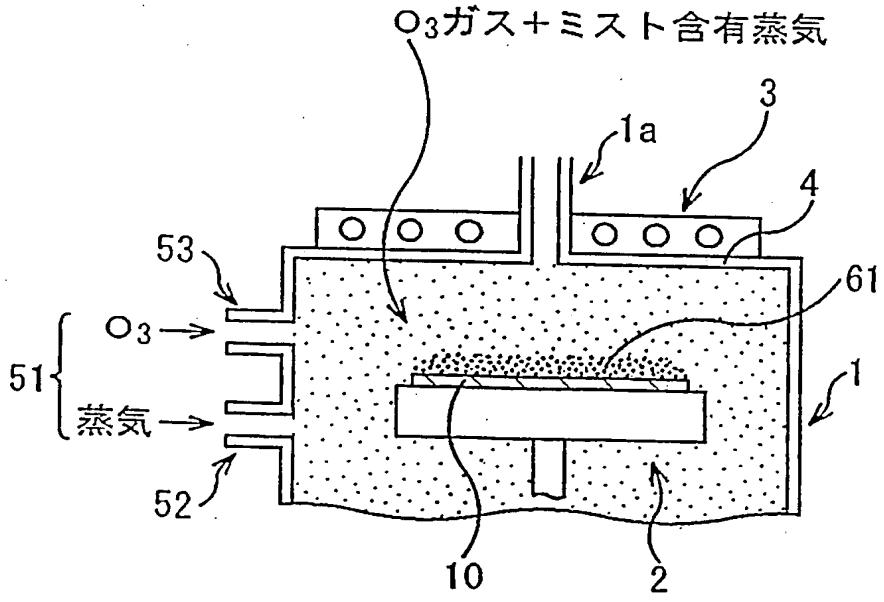
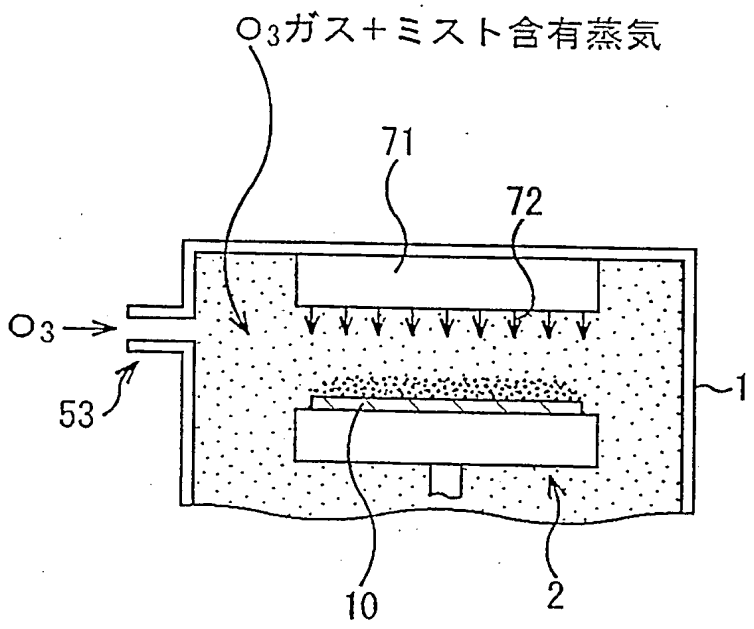


図４



国際調査報告

国際出願番号 PCT／JP03／04751

C（続き）． 関連すると認められる文献

引用文献のカテゴリー＊	引用文献名 及び一部の箇所が関連するときは、その関連する箇所の表示	関連する請求の範囲の番号
A	JP 63－33824 A（大日本スクリーン製造株式会社）1988．02．13（ファミリーなし）	1－21

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP03/04751

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] H01L21/304, B08B3/08, H01L21/30, H01L21/027, G03F7/42

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] H01L21/304, B08B3/08, H01L21/30, H01L21/027, G03F7/42

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1926-1996 Toroku Jitsuyo Shinan Koho 1994-2003
Kokai Jitsuyo Shinan Koho 1971-2003 Jitsuyo Shinan Toroku Koho 1996-2003

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2002-25971 A (Seiko Epson Corp.), 25 January, 2002 (25.01.02), (Family: none)	1-21
A	EP 1088603 A1 (PUREX CO., LTD.), 04 April, 2001 (04.04.01), & JP 2001-340817 A	1-21
A	JP 2001-15472 A (Hoya Shotto Kabushiki Kaisha), 19 January, 2001 (19.01.01), (Family: none)	1-21
A	JP 63-33824 A (Dainippon Screen Mfg. Co., Ltd.), 13 February, 1988 (13.02.88), (Family: none)	1-21

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search
07 July, 2003 (07.07.03)

Date of mailing of the international search report
22 July, 2003 (22.07.03)

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Tel: (03) 3590-8901
Fax: (03) 3590-4801

July 23, 2007

Re: U.S. Patent Application No. 10/510,245
Title: Resist removing apparatus and method of removing resist
Corresponding to: JP2002-113550
Client's Ref: UCRI029
Our Ref: F1143P-WO-US

Dear Mr. Atsushi SATO;
We would like to talk with you about the above case. Please contact us.

****
*** エラー送信レポート ***
****

Unsuccesful transmission sheet (2)

次の送信はエラー終了しました

受付番号	1525
相手先アドレス	0473761871
相手先略称	
開始時刻	07/23 11:01
通信時間	00'00
枚数	0
通信結果	NG # 0018 話し中でした

國分特許事務所
〒170-0013 東京都豊島区東池袋１－17－８ NBF池袋シティビル(5F)
TEL 03(3590)8901 (代)
FAX 03(3590)4801

発信者：柴崎

ファクシミリ送信状

平成１９年7月２３日

送信先： 佐藤 淳 様

下記の書類をお送り致しますので、ご査収の上、宜しくお取り計らい下さいますようお願い申し上げます。

送信枚数（本状を含む） ＿＿＿枚

記

米国特許出願No. １０／５１０，２４５
発明の名称「レジスト除去装置及びレジスト除去方法」
対応日本出願No. 特願２００２－１１３５５０
貴社整理No. ＵＣＲＩ０２９
弊所整理No. Ｆ１１４３Ｐ－ＷＯ－ＵＳ の件
標記の件につきまして、恐れ入りますが弊所宛にご連絡頂きたくお願い申し

(Translation of the undeliverable message)

Sender's e-mail: postmaster@nikonoa.net
Date: September 17, 2007 Friday, 19:07
Recipient's e-mail: shimazaki@r-sipec.jp
Subject: Delivery Status Notification (Failure)

Content: Request to Mr. Atsushi SATO (from Sipec Corporation)

This is automatically generated Delivery Status Notification.

Delivery to the following recipients failed.
Sato.Jun@nikonoa.net

Undeliverable message

S.Shimazaki

差出人: postmaster@nikonoa.net
送信日時: 2004年9月17日金曜日 19:07
宛先: shimazaki@r-sipec.jp
件名: Delivery Status Notification (Failure)


ATT00004.dat


お願い(サイペック(株)島崎) (...

This is an automatically generated Delivery Status Notification.

Delivery to the following recipients failed.

Sato.Jun@nikonoa.net

ウェブ検索結果 (検索結果の見方) "Atsushi SATO""佐藤淳" で検索した結果 1～10件目 / 約19

スポンサーサイト
掲載について

1. メンバー
ksatoh.mcb@mri.tmd.ac.jp. MTT特任助手. 佐藤 淳. Atsushi SATO. sato.mtt@mri.tmd.ac.jp. 特任助手. 大西英理子 ... 中村きよみ. Kiyomi NAKAMURA ...
www.tmd.ac.jp/mri/mri-mcb/menbers.html - キャッシュ

2. 310corp.=サンイチマルコーポレーション=
車の総合商社、グローバルスタンダードを目指して。310corp.サンイチマルコーポレーション=佐藤 淳<Atsushi Sato> ... 431130015105号. リサイクル法 自動車引取業者登録 第20111002711号 ...
www.310co.com - キャッシュ

3. コスモ アースコンシャス アクト
近藤謙二郎--Kenjirou Konndou(足立区・東部障害福祉総合センター) 2月28日(水) 宮沢辰雄--TAtsuo Miyazawa ... 佐藤 淳--Atsushi Sato(「タイド」代表) 2月12日(月) ...
www.tfm.co.jp/earth/archives/2003/mssg/j/viewal!C102-j.html - キャッシュ

4. ajmun'99 | 運営事務局
事務総長 Secretary-General. 砂原庸介 Yosuke SUNAHARA ... 佐藤淳 Atsushi SATO. 議長 (総会第 2 委員会) Chair. 上野和敬 Kazutaka UENO. 議長 (総会第 3 ...
www.jmun.org/ajmun99/secretariat.html - キャッシュ

5. コスモ アースコンシャス アクト
佐藤 淳--Atsushi Sato(「タイド」代表) 2月12日(月) 茨城県高萩市のボランティアグループ、『タイド』の代表・佐藤淳さんは、日本初の「パソコンで読む環境CD-ROMマガジンを1万枚、自主制作し、希望者に無料配布しています。 ...
www.tfm.co.jp/earth/archives/2003/mssg/j/0102-j.html - キャッシュ

6. MAPLL 2007 home
佐藤淳・カフラマン バルシュ・小野創・酒井弘 (広島大学) Atsushi Sato, Baris Kahraman, Hajime Ono, Hiromu Sakai (Hiroshima University) ...
home.hiroshima-u.ac.jp/~cbi/MAPLL2007 - キャッシュ

7. 発生遺伝子制御研究チーム (RDF)
佐藤(淳) 2 ,Han. 2 ,Li. 2 ,野島. 4 ,鷹架. 4 ,岩崎. 4 ,名和 ... Dr. Atsushi SATO(JST, CREST) ... 敦子, 中尾和加子, 中山里実, 内山学, 佐藤淳, 野島康弘, ...
riken.go.jp/r-world/info/release/pamphlet/annual/2001/pdf01/503.pdf - htmlで見る

8. 発生遺伝子制御研究チーム (RDF)
Dr. Atsushi SATO (CREST, JST) ... 下田修義, 小森敦子, 中尾和加子, 中山里実, 内山学, 佐藤 ... 和田浩則, 政井一郎, 西脇優子, 田中英臣, 吉澤あすか, 佐藤. 淳, 野島康弘, ...
riken.go.jp/r-world/info/release/pamphlet/annual/2002/pdf02/0645.pdf - htmlで見る

9. 発生遺伝子制御研究チーム (RDF)

Dr. Atsushi SATO (Tokyo Univ. Technol. ... 佐藤淳, 和田浩則, 坪崎陽一郎, 田中英臣, 西脇優子, 政井 ... 英臣, 佐藤淳, 野島康弘, 岡本仁: "ゼブラフィッシュの顔 ...

riken.go.jp/r-world/info/release/pamphlet/annual/2003/pdf03/0253.pdf - htmlで見る

10. [samba-jp:04745] Linux どうしで SAMBA を ...

送信者: Atsushi Sato at ncsfox.co.jp. 日時: 2000-02-12 02:53:53 ... (なぜNFSにしないいのだと思われるかもしれませんが NFSだと、どちらかが電源が入っていないときに、もう一方がmountが失敗 ...

www.samba.gr.jp/ml/article/samba-jp/msg04728.html - キャッシュ

1 2 次へ

ウェブ検索結果 (検索結果の見方) "Atsushi SATO""佐藤淳" で検索した結果 11～19件目 / 約19

スポンサーサイト
掲載について

11. [samba-jp:04745] Linux どうしで SAMBA を ...
送信者: Atsushi Sato at ncsfox.co.jp. 日時: 2000-02-12 02:53:53 ... (なぜNFSにしないいのだと思われるかもしれませんが NFSだと、どちらかが電源が入っていないときに、もう一方がmountが失敗 ...
www.samba.gr.jp/ml/article/samba-jp/msg04728.html - キャッシュ

12. 発生遺伝子制御研究チーム (RDF)
Dr. Atsushi SATO (Tokyo Univ. Technol. ... 英臣, 佐藤淳, 野島康弘, 岡本仁: "Ilk/scrb1 と ord/celsr2 ... 二階堂昌孝, 佐藤淳, 和田浩則, 田中英臣, 西脇優子, 川上 ...
riken.go.jp/r-world/info/release/pamphlet/annual/2004/pdf04/0742.pdf - htmlで見る

13. hokkaidokyoritz.co.jp/butai/Sound/...
舞台テレビ業務部舞台課音響担当. 主任. 主任
www.hokkaidokyoritz.co.jp/butai/Sound/web-content/NewFiles/Staff.html

14. [JavaHouse-Brewers:30597] Re: sleep ...
From: at_sato@ncsfox.co.jp (Atsushi Sato) ... 佐藤淳といいます。わたしも、その現象で悩んでいたんですよ。... 以上です。- Atsushi Sato E-Mail:at_sato ...
java-house.jp/ml/archive/j-h-b/030597.html

15. ABOUT nokiro-art-net
事業概要. ノキロアートネットは 作家、職人、アーティスト、クリエーターとのネットワークで ... 代表 佐藤 淳 Atsushi Sato. 1973. 広島県福山市に生まれる. 1997. 立命館大学国際関係学部卒業(京都) ...
www.nokiro-art-net.com/aboutus/aboutus.html

16. クウェーサーとはなにか
QUASARとは? 1996.8.25. 同人雑誌であります。QUASARは、創作集団<STAK>が情報を発信するスペースであります。<STAK>とはなにか
faketwins.fc2web.com/docs/about.html

17. [samba-jp:04745] Linux どうしでSAMBAを使うと ...
From: Atsushi Sato <at_sato at ncsfox.co.jp> ... Organization: ニッテツ北海道制御システム. Reply-To: samba-jp at ns.ribbon.or.jp. 佐藤淳といいます。...
www.tac.tsukuba.ac.jp/~yamato/samba/4500/msg00245.html

18. 発生遺伝子制御研究チーム (RDF)
Dr. Atsushi SATO (CREST, JST) ... 下田修義, 小森敦子, 中尾和加子, 中山里実, 内山学, 佐藤 ... 和田浩則, 政井一郎, 西脇優子, 田中英臣, 吉澤あすか, 佐藤. 淳, 野島康弘, ...
www.impcas.ac.cn/lihuasuonb/2002/pdf02/0645.pdf

19. 発生遺伝子制御研究チーム (RDF)
Dr. Atsushi SATO (Tokyo Univ. Technol. ... 佐藤淳, 和田浩則, 坪崎陽一郎, 田中英臣, 西脇優子, 政井 ... 英臣, 佐藤淳, 野島康弘, 岡本仁: "ゼブラフィッシュの顔 ...

www.impcas.ac.cn/lihuasuonb/2003/pdf03/0253.pdf

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